BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D.C. 20024

B 68 11048

SUBJECT: Redundant Molecular Sieve Configuration for CO_2 Removal on AAP-2 - Case 620

DATE: November 18, 1968

FROM: J. J. Sakolosky

ABSTRACT

The AAP-2 (Air Research) and MOL (Hamilton Standard) molecular sieve designs are examined from functional and hardware viewpoints. Design parameters and system schematics are presented for each. A number of integration problems that would be encountered in combining the two different designs into an on-line/stand-by redundant system are discussed. It is concluded that if the LiOH is removed from AAP-2, the molecular sieve replacing it should be the Air Research design.

(NASA-CR-100205) REDUNDANT MOLECULAR SIEVE CONFIGURATION FOR CARBON DIOXIDE REMOVAL ON AAP-2 (Bellcomm, Inc.) 12 p

N79-73048

Unclas
00/54 11371

BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D.C. 20024

B68 11048

SUBJECT: Redundant Molecular Sieve Configuration for CO_2 Removal on AAP-2 - Case 620

DATE: November 18, 1968

FROM: J. J. Sakolosky

MEMORANDUM FOR FILE

INTRODUCTION

One means of improving the AAP-2 performance margin is to replace the LiOH, which is a backup means for CO_2 removal, with a second molecular sieve. The new CO_2 removal system would then consist of an on-line molecular sieve with a stand-by molecular sieve providing a backup capability. Since a molecular sieve has never been operated in zero-G environment, some doubts exist as to the reliability of this all-molecular-sieve CO_2 removal system. Some unpredictable failure that might disable both CO_2 removal systems could occur as a result of the new environment. It has been proposed that the probability of this type of catastrophic failure could be minimized by using a MOL (Hamilton Standard) molecular sieve rather than the AAP (Air Research) molecular sieve as the backup system. This memorandum will investigate various aspects of the Air Research and Hamilton Standard molecular sieves and whether a system using both offers any significant advantages over a system using two of a single design. Appendix A lists the design parameters associated with each sieve. Appendix B indicates the level of redundancy incorporated in each design.

TRADEOFF CONSIDERATIONS

Maximum confidence in the ability of both primary and backup systems to avert the same catastrophic failure mode will occur if the two systems being considered are of different basic design concepts, such as LiOH and a molecular sieve or a molecular sieve and a molten carbonate CO_2 removal system. If the basic design of the two systems is not different, then at least one would like the systems to be functionally different, e.g. electric actuation versus pneumatic actuation of the gas selector valves or mechanical timing versus electronic timing of the adsorption/desorption cycle. This would imply a significant hardware difference between the two systems and the probability of significantly different failure modes. If the on-line and stand-by systems are not functionally different, then the hardware differences between the two systems are probably minor, and it is unlikely that the stand-by system will be able to avert a zero-G failure mode which has disabled the on-line system. In this case the most desirable redundant configuration would use the most reliable of the candidate systems in both the on-line and stand-by positions.

COMPARISON OF AAP and MOL MOLECULAR SIEVES

The basic design concept of both the AAP and the MOL molecular sieves is the same. Both systems incorporate a two-bed adiabatic design with vacuum desorption. A functional comparison of the two molecular sieves is shown in Table I. From the Table, it is obvious that the two molecular sieves are functionally identical.

A parts list for each of the sieve designs is shown in Table II. The major hardware difference between the two molecular sieves is the gas selector valve for controlling air flow through the bed canister. The AAP design utilizes a five port valve in contrast to the three port valve employed by the MOL sieve. The valves are actuated pneumatically through oxygen pressurization in both designs. In most other cases, the corresponding hardware is of similar basic design and operation. The manual interconnect valves associated with the AAP sieve constitute an added level of redundancy and are used only in the case of a solenoid valve failure. A schematic for each molecular sieve design is given in Appendix C.

INTEGRATION PROBLEMS

A number of integration problems would be encountered in combining an on-line Air Research molecular sieve with a stand-by Hamilton Standard molecular sieve. Both sieves may be subjected to pre-launch bake-out for the removal of any initial contamination within the bed. The Air Research design utilizes the heaters imbedded within the molecular sieve material and a vacuum pump to simulate the bake-out conditions as they will occur in orbit. The Hamilton Standard design uses a hot gas purge for pre-launch bake-out. A common pre-launch bake-out procedure would be preferable if the two designs are combined in a redundant system.

The Air Research molecular sieve is designed for a three man crew while the Hamilton Standard design is for a two man crew. The atmospheric composition flowing through the sieves is also different. AAP uses a two gas oxygen/nitrogen atmosphere whereas MOL utilizes an oxygen/helium atmospheric composition. Additional testing would undoubtedly be required to verify that the Hamilton Standard design would perform satisfactorily for a three man crew and the AAP cabin atmosphere.

A number of additional problems are likely to be encountered in combining the two molecular sieves in a single system. Since the molecular sieves were designed for launch on different vehicles, it is very likely that the vibrational and acceleration requirements are different for the two designs.

TABLE I

FUNCTIONAL COMPARISON OF AAP AND MOL MOLECULAR SIEVES

Function	AAP Molecular Sieve	MOL Molecular Sieve
1. Water Adsorption	Molecular Sieve 13X	Molecular Sieve 544
2. Carbon Dioxide Adsorption	Molecular Sieve 5A	Molecular Sieve 522
3. Desorption	Vacuum Vent	Vacuum Vent
4. Cycle Timing	Electronic	Electronic
5. Bed Bake-out	Electrical Heater	Electrical Heater
6. Gas Selector Valve Actuation	Pneumatic (Oxygen Pressurization)	Pneumatic (Oxygen Pressurization)
7. Pressurization Control	Solenoid Valves	Solenoid Valves

TABLE II

HARDWARE COMPARISON OF AAP AND MOL MOLECULAR SIEVES

	Component	No.	AAP Molecular Sieve	No.	MOL Molecular Sieve
1.	Sorbent Canister	2	Linde Type 5A, 13X mol sieve	2	Davidson Type 522, 524 mol sieve
2.	Contaminant Removal Canister	1	Charcoal	1	Chemisorbent
3.	Valve, Gas Selector	2	Pneumatic, five way	2	Pneumatic, three way
4.	Valve, Oxygen Pressurization	4	Solenoid, three way	4	Solenoid, three way
5.	Valve, Interconnect	4	Manual, three way		------
6.	Valve, Double Check		------	2	Canister to cabin line
7.	Auto. Cycle Timer	2	Electronic	1	Electronic
8.	Heater Temp. Control	2	Redundant configuration	1	Non-redundant
9.	Gas Filter	1	10 micron nominal		------

Additional testing would be required to qualify the Hamilton Standard molecular sieve for an SIVB launch. Additional testing would also be required to verify that the Hamilton Standard design will desorb to space adequately through the Airlock Module vacuum vent configuration. The electrical connectors on the Hamilton Standard design are different from those being used in the Airlock Module and would have to be changed. There are the additional problems of increased crew training requirements and increased operational complexity associated with the combination of two unlike designs. The increased systems familiarization requirement pertains to the installation crew as well as the flight crew. Although not directly measurable, it is possible that the increased complexity could result in degraded performance of the crew.

CONCLUSIONS

If the LiOH presently baselined aboard AAP-2 is removed as a result of weight considerations, it is the author's opinion that the backup system replacing it should be an additional Air Research (AAP) molecular sieve.

The motivation for combining two different sieve designs in the redundant configuration results from an effort to decrease the chance that any single unexpected failure mode attributed directly to the zero-G environment could completely disable the CO_2 removal system. However, in basic design concept, functional operation, and component hardware, the Air Research and Hamilton Standard designs are very similar. Thus, it is unlikely that the two systems will have significantly different failure modes which can be attributed directly to the zero-G environment. This is not to say that the failure modes of the two different designs would be the same. Failure mode differences resulting from quality and workmanship differences may very likely exist. However, these are the type of defects which can be eliminated by thorough ground testing. The point to be made is that if zero-G design deficiencies exist in the Air Research design, then they probably exist in the Hamilton Standard design also.

A number of integration problems associated with combining the two different designs in a redundant system also argue against the incorporation of two different sieves in AAP-2. Granted that none of these problems is insurmountable,in combination they would likely add to increased cost and perhaps schedule delays. At the very least, they add complexity with little hope of any measurable compensating gain.

A final point which favors the use of a backup Air Research molecular sieve is its higher level of built-in redundancy. Appendix B indicates that the Air Research design offers redundant operations for dealing with six predictable failure modes; the Hamilton Standard design offers redundancy or maintainability to cope with three of these failures.

J. J. Sakolosky

1022-JJS-ms

J. J. Sakolosky

Attachment
Appendices A, B, C

REFERENCES

1. Airlock Preliminary Design Review Data Package, McDonnell-Douglas Corporation, November 29, 1967.

2. Evaluation of AAP Airlock Module Molecular Sieve CO_2 Removal Subsystem Proposals, C. Crews and Luino Dell'Osso, Jr., Crew Systems Division, Manned Spacecraft Center, December 14, 1967.

3. MOL Data Book, Volume I, System Configuration Data, Sequence Number B278, Douglas Missile and Space Systems Division, McDonnell-Douglas Corporation, June 30, 1968. Bellcomm Reference No. 68-4038 (SECRET DOCUMENT).

4. Personal Communication, E. J. Wulf, Hamilton Standard Division of United Aircraft Corporation, November 4, 1968.

5. Personal Communication, L. Calhoun and M. Peeples, McDonnell-Douglas Corporation, September 23, 1968.

APPENDIX A

DESIGN PARAMETERS: AAP AND MOL MOLECULAR SIEVES

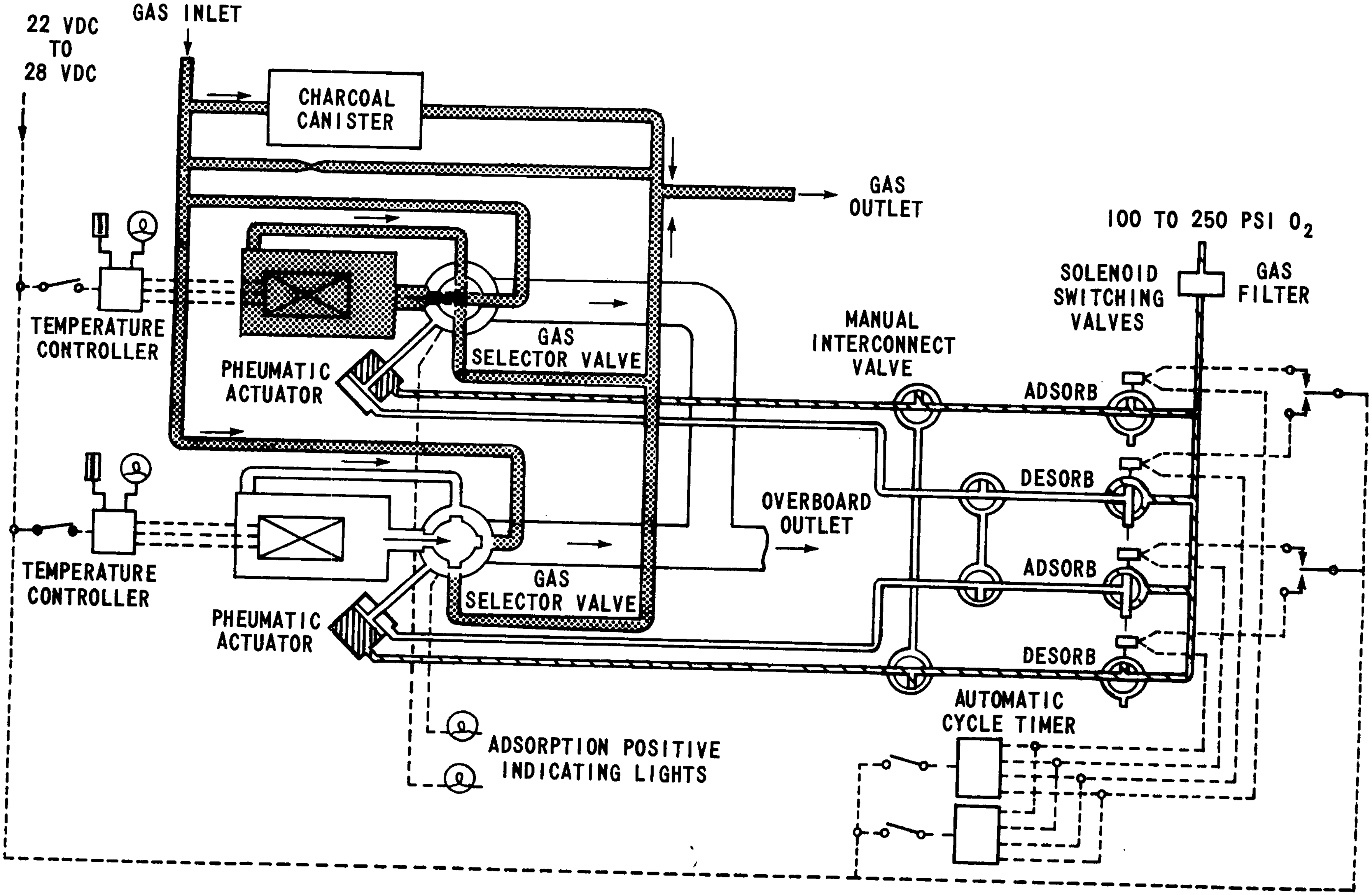
	AAP (Air Research)	MOL (Hamilton-Standard)
Type	2 Bed Adiabatic, Vacuum Desorb	2 Bed Adiabatic, Vacuum Desorb
Weight	135 lbs.	83 lbs.
Power	3.8 W Nominal, 360 W Bake-out	~5.3 W Nominal, 150 W Bake-out
CO_2 Removal Rate	6.75 lbs/day	5.46 lbs/day
Cycle Time	30 Minutes; 15 Absorb, 15 Desorb	28 Minutes; 14 Absorb, 14 Desorb
Cabin Atmos. Loss	1.5 lbs/day	1.08 lbs/day
H_2O Adsorption Bed	Linde Type 13X	Davidson Type 544
CO_2 Adsorption Bed	Linde Type 5A	Davidson Type 522
Interfaces	Electrical Power High Pressure Oxygen Space Vacuum	Electrical Power High Pressure Oxygen Space Vacuum
Total Pressure	5 psia: 3.7 psia O_2, 1.3 psia N_2	5 psia: 3.5 psia O_2, 1.5 psia He
Volume	~ 28" x 26" x 14"	14.4" dia. x 21.2" length

APPENDIX B

REDUNDANT FEATURES OF AIR RESEARCH AND HAMILTON STANDARD MOLECULAR SIEVES

	Failure	Nature of Redundancy	
		Air Research	Hamilton Standard
1.	Cycle Timer	Redundant timer	Spare timer
2.	Solenoid Valve	Manual interconnect bypasses failed valve	Spare valve
3.	Bake-out Heater Temperature Controller	Redundant temperature controller	No redundancy
4.	Irreversible Contamination of One Bed	Degraded operation with one bed	Degraded operation with one bed
5.	Pneumatic Actuation of Gas Selector Valves	Manual actuation	No redundancy
6.	Automatic Actuation of Solenoid Valves	Manual (electric) switch	No redundancy

APPENDIX C
AIR RESEARCH MOLECULAR SIEVE SCHEMATIC



APPENDIX C
HAMILTON STANDARD MOLECULAR SIEVE